

UNITED STATES PATENT APPLICATION

OF

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**TITLE: ELECTRONIC CIRCUIT WITH REVERBERATION
EFFECT AND IMPROVED OUPUT CONTROLLABILITY**

ELECTRONIC CIRCUIT WITH REVERBERATION EFFECT AND IMPROVED OUTPUT CONTROLLABILITY

CROSS-REFERENCE TO RELATED APPLICATIONS

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This application is a continuation-in-part application of my prior application U.S. Ser. No. 10/757,833, filed January 14, 2004, entitled "Electronic Circuit with Reverberation Effect and Improved Output Controllability, the disclosures of which, including all attached documents, are incorporated herein by reference in their entirety
10 for all purposes.

FIELD OF THE INVENTION

The present invention relates in general to an electronic circuit for accepting a
15 high impedance audio signal and adding spring reverberation effect thereto while maintaining an acceptable impedance range for input into an external sound device such as a guitar amplifier, pedal effects device or any other instrument level device.

BACKGROUND OF THE INVENTION

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Reverberation is the collection of reflected, discrete sounds or echoes generated from surfaces in an enclosure like an auditorium. Musicians, audiophiles and the like strive to add reverberating effects in recordings and live performances to place a sound within the context of its space or create new sounds of their own, not necessarily relating
25 to any existing physical space. The prior art currently offers electronic reverberation units or techniques which can simulate a number of acoustic environments and give control over the amount of reverberation added to an audio signal. One notable technique is convolution, which involves recording the ambience of a room under controlled conditions and superimposing the resultant recording onto a sound recorded elsewhere.

A less costly and more practical approach of reverberation is the spring reverb, which is often electronically made part of some sound mixing boards, pedal effect devices, pre-amplifiers, and guitar amplifiers. Inherent in these devices is the lack of varied means for controlling or manipulating the reverberation effect besides that of the reverberation device such as through the use of an external amplifier or an effects pedal device for improved replication of an acoustical space or increased production of a new sound effect. In most design configurations, the reverberation device, whether it is analog or digitally based, comprises means for accepting an audio signal from a musical source and combining the signal with effects of reverberation followed by amplification collectively occurring internally therewithin. The extent to which reverberation is added to the audio signal and manipulated is primarily controlled at the interface of the of spring reverberation device rather than through other available sound enhancing means. Consequently, limitations are immediately placed upon the musician in attempting to simulate a particular acoustical space, create entirely new sound effects, or replicate sounds of the past, specifically the warm “vintage sound” so often associated with the preferred tube driven spring reverberation devices of the 50’s and 60’s.

In accordance with the present invention, applicant has appreciably devised an electronic circuit which provides for varied alteration or manipulation of the reverberation effect besides that of the reverberation device to offer the musician or audiophile versatile means to enhance replication of an acoustical space or create entirely new sounds during a recording session or live performance.

BRIEF SUMMARY OF THE INVENTION

In order to overcome the numerous drawbacks apparent in the prior art, a electronic circuit incorporating reverberation has been devised for use with an external sound device such as a guitar amplifier, pedal effects device or other instrument level devices often employed in recordings and live performances.

It is thus an object of the present invention to provide a low cost, non-complicated device which may be reliably used in enhancing the reverberation effect to more accurately simulate a preexisting acoustical environment substantially by means other than those generally made available at the reverberation device.

5 It is another object of the present invention to provide such an electronic circuit incorporating reverberation which affords versatility to the musician to permit production of sounds not necessarily associated with or related to a known acoustical space.

It is another object of the present invention to provide such an electronic circuit incorporating reverberation which possesses audio signal outputs comprising an
10 impedance level substantially equivalent to an audio signal produced by a musical source such as an electric guitar pickup, harmonica microphone, or other high impedance instrument output.

It is another object of the present invention to provide such an electronic circuit incorporating reverberation which is portable for convenient transport to recording
15 sessions and live performances and compatible with most vintage amplifiers lacking in most cases means for adding the effect of reverberation such as a tube driven amplifier.

It is another object of the present invention to provide such an electronic circuit incorporating reverberation which comprises an audio signal bypass of suitable
impedance for input into a two channel amplifier to increase the effectiveness of the
20 reverberation effect or newly created sounds.

It is yet another object of the present invention to provide such an electronic circuit incorporating reverberation which accomplishes the foregoing and other objects and advantages and which is economical, durable, and fully effective in performing its intended functions without undue retrofitting of existing sound equipment, including
25 without limitation, amplifiers, effects pedal device, sound mixing boards, etc.

In accordance with the present invention, an electronic circuit incorporating reverberation has been devised for use with an external sound device such as an amplifier

or an effects pedal device, the electronic circuit comprising in combination a reverberation effects circuit having a pre-amplifier/driver and recovery amplifier sections and a spring reverberation device coupled thereinbetween, the pre-amplifier/driver section having an input jack for receiving therethrough a high impedance signal produced from an external audio source and a low impedance, high current output for input into the spring reverberation device having an output for passing a low impedance signal to the recovery amplifier section, which suitably increases the impedance of the signal to a predetermined level acceptable for input into the external sound device, and a power supply circuit having means for switching between a dc voltage source and an ac voltage source and supplying ± 9 volts to integrated circuits (ICs) included in the pre-amplifier/driver and recovery amplifier sections of the reverberation effects circuit.

Other objects, features, and advantages of the present invention will become apparent in the following detailed description of the preferred embodiments thereof when read in conjunction with the accompanying drawings in which like reference numerals depict the same parts in the various views.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

A preferred embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a schematic diagram illustrating a reverberation effects circuit of the preferred embodiment of the present invention;

FIG. 2 is a schematic diagram illustrating a power supply circuit of the preferred embodiment of the present invention;

FIG. 3 is a block diagram depicting signal flow through a preferred embodiment of the present invention;

FIG. 4 is a block diagram illustrating the preferred embodiment of the present invention in a two-channel configuration; and

FIG. 5 is a block diagram illustrating the preferred embodiment of the present invention in a one-channel configuration.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

While this invention is susceptible of being embodied in many different forms, the preferred embodiment of the invention is illustrated in the accompanying drawings and described in detail hereinafter with the understanding that the present disclosure is to be considered to exemplify the principles of the present invention and is not intended to limit the invention to the embodiments illustrated and presented herein. The present invention has particular utility as a device for adding and enhancing the effects of reverberation while maintaining an impedance level made suitable for application with external sound devices such as a guitar amplifier, an effects pedal device, or other instrument level device.

Referring to FIG. 1, there is shown generally at 10 a schematic diagram of the reverberation effects circuit of the present invention driven by a power supply circuit switchable between a conventional high current, low impedance source and a low dc voltage source consisting of a pair of 9 volt batteries as collectively represented in FIG. 2. A relay RL1 operatively switches the power source from dc to ac particularly occurring upon an outside power source of 120vac/60Hz being coupled to a transformer T1, notwithstanding the presence of the low dc volt source. In this regard, the power supply is responsive to voltage from a line connection, through transformer and a mono phone jack J1, and includes a conventional rectifying circuit as established by a pair of diode/capacitor groupings of D1, C1 and D2, C2, each grouping of which serving as an appropriate filter for converting an ac voltage source to dc, which is needed to operate a plurality of integrated circuits (ICs) integrally made part of the amplifying sections of the

reverberation effects circuit. Given that each of the ICs operate at a specified voltage as determined by the manufacturer, the power supply circuit further comprises a pair of adjustable voltage regulators IC1, IC2, which, acting in concert with a pair of resistor groups R1, R2 and R3, R4, respectively, suitably establishes bipolar outputs of 9 volts at approximately 125 milliamps. To further serve in filtering the signal and mitigating the presence of voltage spikes prior to being fed into and coupled to relay RL1, voltage line outputs from IC1 and IC2 each comprise a diode/capacitor grouping of D3, C3 and D4, C4, respectively. As shown in FIG. 2, RL1's normally closed contacts are coupled to 9 volt batteries while the normally open contacts are coupled to the bipolar outputs from IC1 and IC2. Upon coupling the external power supply of 120vac/60Hz to T1, RL1 energizes and closes the NO contacts which effectively disconnect the 9 volt batteries from the reverberation effects circuit, more specifically the ICs. Conversely, when T1 is disconnected from the 120vac/60Hz source, the ICs become operational from the 9 volt batteries via J4 and J5 phone jacks. Only upon the instance of J4 and J5 being coupled to an external phone plug will the batteries supply power to the reverberation effects circuit, otherwise the batteries will not have a return path to ground. This arrangement effectively serves as a visual safeguard against inadvertently leaving the circuit powered up strictly under battery power.

Referring now to FIG. 1, the reverberation effects circuit further comprises a pre-amplifier/driver circuit 12 for conditioning the audio signal input prior to being fed into a reverb pan RP, particularly in terms of setting the correct impedance at the input side of the RP and establishing ample current to drive the transducers inherently made part of the RP and a recovery amplifier section 14 for increasing the signal impedance to a predetermined level prior to being passed to an external sound device. First and second operational amplifiers IC3a and IC3b form the pre-amplifier/driver section of the reverberation effects circuit which primarily amplifies and controls the audio input signal prior to being fed into the input transducer of RP. Audio input signal is initially applied at input connection J2 and branches into two discrete signal pathways, one of which

extending from the input to an open phone jack J4, which substantially serves as a reverberation effects bypass, and a second pathway extending to a switch SW1. In a closed state, SW1 passes the audio input signal to the non-inverting input of IC3*b* via R6, which pads the audio signal prior to reaching IC3*b* to prevent possible overloading into

5 IC3*b* which may lead to undesirable distortion and noise. A path to ground via R7 prior to passing the signal to the inverting input of IC3*b* substantially serves in keeping an audio signal feed of a guitar or other high impedance source from being loaded into IC3*b*. A path to ground from J2 effectively serves in protecting signal from noise caused by the presence of RFI and EMI. Amplifier IC3*b* is operated with a negative feedback

10 comprising a 50K linear potentiometer VR1 having variable resistive capacity to appropriately adjust the gain at the output path of IC3, specifically in light of the resistive value of R5 being selectively coupled to the inverting input of IC3*b*. In an operative state, the feedback voltage is dropped by the varying resistive values of VR1 and shunted to ground via R5 and J2, collectively establishing an output at IC3*b* having a low

15 impedance, low noise response and a gain factor approaching upwards of 23. The output pathway of IC3*b* is coupled to the non-inverting input of IC3*a* via a pair polarized capacitors C5, C6, which appropriately serve to block the passing of any dc signal into IC3*a* while permitting the passage of the audio signal for eventual input into RP.

Powering of the dual op-amps IC3*a*, IC3*b* is principally established by the ± 9 volt rails

20 from the power supply circuit noted above. A path to ground for the negative and positive voltage leads each incorporate a capacitor C9 and C10, respectively, to suitably filter and establish steady line voltage to IC3*a* and IC3*b*. To moderately increase the gain at low frequencies at IC3*a* and minimize the gain at high frequencies to the extent of enhancing the effects of reverberation, the inverting input of IC3*a* is supplied with a

25 resistor/capacitor arrangement R8, C7 shunted to ground. The presence of C7 at the ground path of the inverting input effectively serves in filtering or rolling off a predetermined amount of high frequencies and limits the extent of high frequency feedback at the inverting input in the event VR1 is set at a high resistive level. Output from IC3*a* is coupled to the input side of RP and comprises a negative feedback loop

having also a resistor/capacitor arrangement R9, C8, which collectively stabilizes the feedback loop and restores phase margin to the IC3a networked circuitry. A path to ground from the input side of RP is provided and terminates at the feedback loop of IC3a prior to and after the resistor/capacitor arrangements of R8, C7 and R9, C8, respectively.

- 5 In preferred applications, RP comprises a spring reverberation device of the type having a 3-spring configuration operable at an input impedance of 800 ohms and an output impedance of 2575 ohms, as notably manufactured by Accutronics as Model No. 8EB2C1B. It is noted herein, however, that standalone reverberation devices manufactured by companies other than Accutronics may be suitable for this application
- 10 providing they meet the above specifications and cooperate with and operate within the limitations of the ICs integrally made part of the amplifier/driver and recovery amplifier sections of the reverberation effects circuit.

- Referring now to the recovery amplifier section **14** of the reverberation effects circuit **10** in FIG. 1, a reverberated output signal from RP is coupled to the inverting input
- 15 of IC4 via a resistor/capacitor arrangement R10, C11, whereas C11 primarily serves in the capacity of rolling off the low frequency gain of the circuit prior to reaching IC4. A path to ground is provided for the non-inverting input and the inverting input via capacitor C12 to mitigate high frequency feedback at the output of IC4. Like IC3b, IC4 comprises an output signal incorporating a negative feedback loop but comprises a 100K
- 20 linear potentiometer VR2 to suitably establish a gain factor of approximately 5 at the output of IC4, as cooperatively established by the resistive capacity of R10. The higher resistive capacity of VR2 in light of the value for VR1 suitably allows adjustment of the gain to correspond more fully with the gain outputs at VR1 of the pre-amplifier/driver circuit regardless of the level of reverberation added to the audio signal. In other words,
- 25 the varying resistive capacities of VR1 and VR2 and the upward resistive limit of VR2 collectively serve in retaining the desired amount of reverberation, as principally controlled by the dwell control at VR1, and amplifying the reverberated signal to a predetermined gain for a more predominant positioning in the soundstage. Powering of

IC4 is principally established by the ± 9 volt rails from the power supply circuit noted above. Each of the ± 9 volt rails receive a diode D6, D5 for filtering applied voltage and ensuring correct polarity passing into IC4. A path to ground for the negative and positive voltage rails each incorporate a capacitor C13 and C14, respectively, to suitably filter and establish steady line voltage to IC4. Output signal from IC4 is directed to an output phone jack J5 via capacitor C15, which suitably serves in filtering voltage spikes to ensure steady line voltage to an external sound enhancing device such as a guitar amplifier or effects pedal device. Coupled in between C15 and J5 is path to ground passing through resistor R11 to reinforce the impedance strength of the signal exiting IC4 and ensure impedance matching with that of the external sound enhancing device. An input jack J3 comprising a switch SW2 provides means for clamping a signal to ground, which is useful in controlling sound effects at the external sound device intermittently during a performance or recording session. A schematic of signal flow through the reverberation effects circuit is provided in FIG. 3.

Table 1 attached hereto lists the values of the circuit components described herein. However, it is to be understood that the invention is not limited to the precise circuit values or even the specific embodiment described above, and no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It can be appreciated that numerous variations and modifications may be effected without departing from the true spirit and scope of the novel concept of the invention. It is of course intended to cover by the appended claims all such modifications as fall within the scope of the claims.

TABLE 1

C1,C2	2200 uf/16V electrolytic capacitor
C3,C4	1 of 35 V Tantalum capacitor
IC1	LM317 Adj. +9 volt regulator
IC2	LM337 Adj. -9 volt regulator
R1, R4	180 ohm $\frac{1}{4}$ watt metal film resistor
R2, R3	1.15k $\frac{1}{4}$ watt metal film resistor

	D1-D4	1 n4001 diode
	RL1	24 volt dpdt dip relay
	SW1, SW2	spst Carling footswitch
	R5, R9	2.2k ¼ watt metal film resistor
5	R6	1k ¼ watt metal film resistor
	R7	1 M ¼ watt metal film resistor
	R8	47 ohm ¼ watt metal film resistor
	R10	22K ¼ watt metal film resistor
	R11	10K ¼ watt metal film resistor
10	D5, D6	In914 diode
	C5, C6	47uf/50v electrolytic capacitor
	C7	100uf/50v electrolytic capacitor
	C8	.01 of/100v polyester film capacitor
	C9, C10	.1 of/50v polyester film capacitor
15	C11	.22uf/50v polyester film capacitor
	C12	270pf ceramic disc capacitor
	C13, C14, C15	100uf/25v electrolytic capacitor
	VR1	50K linear potentiometer
	VR2	100K linear potentiometer
20	IC3a, IC3b	5532 Dual Operational amplifier
	IC4	741 Single Operational amplifier
	J 1	3.5 mm mono phone jack
	J 2	¼" mono closed phonejack
	J 3	¼" mono open phone jack
25	J4, J5	¼" stereo open phonejack
	T1	120 vac primary/12 vac secondary, rated @ 500 mA
		w/3.5 mm phone plug
	B1, B2	9 volt Alkaline Battery
	RP	Accutronics® Model 8EB2C1B
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In operation, a musical instrument such as a guitar or a harmonica microphone having an output line feed is coupled to J2. Activating SW1 simultaneously provides passage of the audio signal to the reverberation effects circuit for addition of reverb and directly into the external sound enhancing device such as a guitar amplifier, effectively bypassing the addition of reverberation. In a two-channel configuration as shown in FIG. 4, which comprises dedicated controls for both channels at the amplifier, the guitar's direct output is coupled to one channel and the audio signal exiting the reverberation effects circuit via J5 is coupled to the second channel. Using this configuration, the

dwelt and output level controls referred herein as VR1 and VR2, respectfully, together with the volume and tonal controls of the amplifier collectively serve as further means for controlling the effects for reverberation for a more accurate simulation of an acoustical space or creation of a new sound effect. In a one-channel configuration as shown in FIG.

5 5, which comprises two instrument inputs at the amplifier, the effects of reverberation is balanced with the guitar's direct sound through use of VR1 and VR2 at the reverberation effects circuit. Regardless of the configuration of connectivity, the reverberation effects circuit outputs J4 and J5 are preferably fitted with shielded cable of the guitar or microphone type utilizing a 1/4" phone plug. Final operational setup involves configuring
10 the power supply circuit to accept either ac voltage from an outside 120 vac/60Hz power source or dc voltage supplied by a pair of 9 volt batteries. In a configuration utilizing ac power, T1 is coupled to J1 with line inputs of T1 being coupled to an external 120vac/60Hz power supply. In a configuration utilizing dc power, the reverberation effects circuit is operational upon installing a pair of 9 volts batteries, connecting cables
15 of suitable type to J4 and J5, and disconnecting T1 from the power supply circuit. Following the application of power to the reverberation effects circuit and guitar amplifier, the guitar amplifier is activated while the volume controls of the amplifier are adjusted accordingly for each channel. VR1 (dwelt) suitably controls the extent to which reverberation is added to the audio signal, while VR2 controls the level of the reverb
20 signal. To remove the effects of reverberation from the amplified signal, depress SW 1. To re-activate the effects of reverberation, depress SW 1 one additional time.

To create distinct sounds for application during recordings and live performances, the reverberation effects circuit outputs J4 and J5 can be coupled in a particular manner with an external amplifier having instrument inputs for each channel and audio control
25 capabilities (e.g., base, treble and volume). For instance, the reverberation effects circuit output at J5 can be coupled to a tremolo channel of the external amplifier, while the direct signal output at J4 can be coupled to a normal channel of the amplifier to create a realistic echo effect by utilizing the frequency and depth controls of the external amplifier

and VR1 and VR2 at the reverberation effects circuit. In an another example, the depth of the reverberation effect can be effectively increased by passing the signal from an external audio source (e.g., guitar) into an external reverberation amplifier via J4 and coupling J5 to the normal channel of an external amplifier for simultaneous reverberation effect from two sources. Although the present invention is described by way of example to cooperate and function with an external amplifier, other applications may be utilized to facilitate the addition of reverberation to an audio signal given that the input at J2 can accept a high impedance source and that the outputs at J4 and J5 can pass along a high impedance signal matching most other instrument devices, including without limitation modern console pre-amplifiers with direct injection (DI) for balancing line level outputs and pedal type effect units. In this regard, instrument devices of these types may be coupled to J2 or J5 without adversely impacting the reverberation effects circuit.

While there has been shown and described a particular embodiment of the invention, it will be obvious to those skilled in the art that various changes and alterations can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and alterations as fall within the true spirit and scope of the invention.